Chapter 12
Evaluation of Test Fill Results

12-1. General

It has been shown in the previous portions of this manual that information accumulated from a test fill program consists of both qualitative and quantitative data. In analyzing that data and drawing conclusions for design purposes, it is necessary to consider all the data in that qualitative data should not be neglected or ignored even in the presence of strong quantitative data. This is true because quantitative data previously addressed is subject to considerable variation with location in a rockfill, may not be completely representative, or may have been obtained by methods which are not standardized. The remainder of this chapter will be directed at describing the typical usages of gathered data in assessing the placement and compaction procedures.

12-2. Settlement Data

Settlement data have generally been the most useful information for determining the best combination of loose-lift thickness, number of passes, roller type (compaction effort), and material gradation. Settlement data are normally plotted with settlement as the ordinate (y-axis) and actual loose-lift thickness as the abscissa (x-axis) and for each two passes of the roller. Of course, settlement can also be plotted against any of the other listed variables. The type plot used will be dependent upon the variable to be evaluated, but the data should always be plotted in several ways since some relationships will be more apparent in one form of plot compared with others. The settlement readings may be expressed as the actual values in cm or inches or as a percentage of the loose-lift thickness. If, as usual, settlement is to be compared for different loose-lift thickness, it is preferable to express it as a percentage of the loose-lift thickness because that number represents a relative densification. Figures 12-1 through 12-4 show example plots of percent settlement versus roller passes. Figure 12-5 through 12-7 show example plots of percent settlement versus loose-lift thickness.

12-3. Roller Passes

In evaluating the number of roller passes, economics must be considered in that a true optimum based on performance alone can rarely be selected. Instead, consideration must be given to the relative amount of additional settlement or compaction gained for additional passes as indicated by the slope of the settlement versus number of passes curve. Figures 12-1 through 12-4 show that in most (but not all) instances the curves tend to decrease in slope with number of passes even though the decrease may be relatively subtle. These figures also offer some comparative cases among different types of rollers. In addition, visual observations of the inspection trench and results of in situ density and percolation tests must be factored in to make a judgment based on the highest return for the effort put forth and the actual needs of the embankment, i.e., height, seismic risk, etc. More compaction can almost always be obtained by more passes, but the price that must be paid to achieve it becomes increasingly high and perhaps unjustified.

12-4. Gradation Data

Gradation data are usually obtained on the rockfill material before spreading and compaction and after compaction. Intermediate gradations have also been taken such as after certain numbers of passes of the roller or even after spreading if alternate spreading operations are under consideration to reduce material breakdown such as between rubber-tired equipment and the crawler tractor. Figures 12-8 through 12-12 show typical before- and after-compaction gradation curves. These figures were also selected because they compare vibratory rollers with 45-Mg (50-ton) rubber-tired rollers.

12-5. In Situ Density Data

In considering in situ density data, it is well to bear in mind the previous discussions concerning the major source of the shear strength between a sound rockfill and that which contains considerable fines. For sound rock, the key to its strength is interlocking among the larger particles which are segregated toward the bottom of the lift even if fines are generated on the surface of the lift. For materials containing appreciable fines mixed throughout the material such that the larger rocks tend to be separated and “float” within the finer fraction, the shear strength and compressibility will reflect the density of the mass much more directly. For fill composed of sound rock, in situ density numbers are of lesser interest than the observation that the lifts are expectably segregated and stratified with interlocking of the larger particles. For “dirtier” rockfill where the fines will control the strength and compressibility, variability of in situ density with type of roller, number of passes, loose-lift thickness, and use of water is of much greater importance. The Seven Oaks Dam test fill program included an unusually large number of 1.2-m (4-ft) diameter, water-volume, ring density tests.

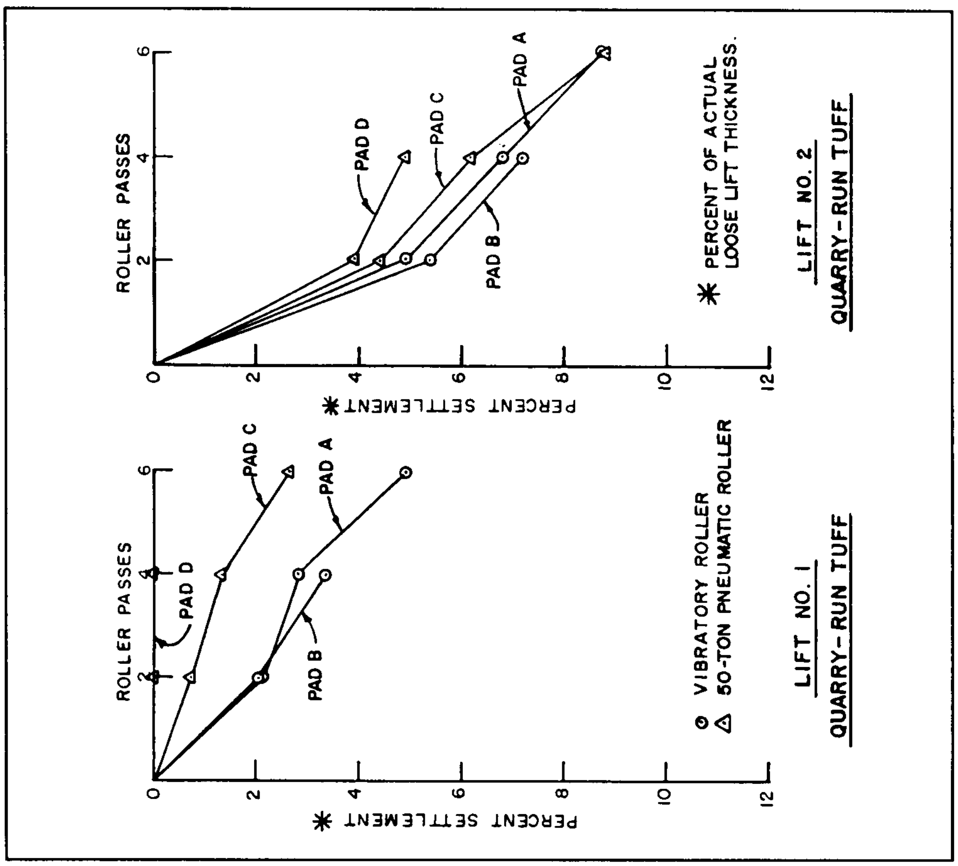

Figure 12-1. Percent settlement versus roller passes, lifts 1 and 2, test fill 4A, Cerrillos Dam

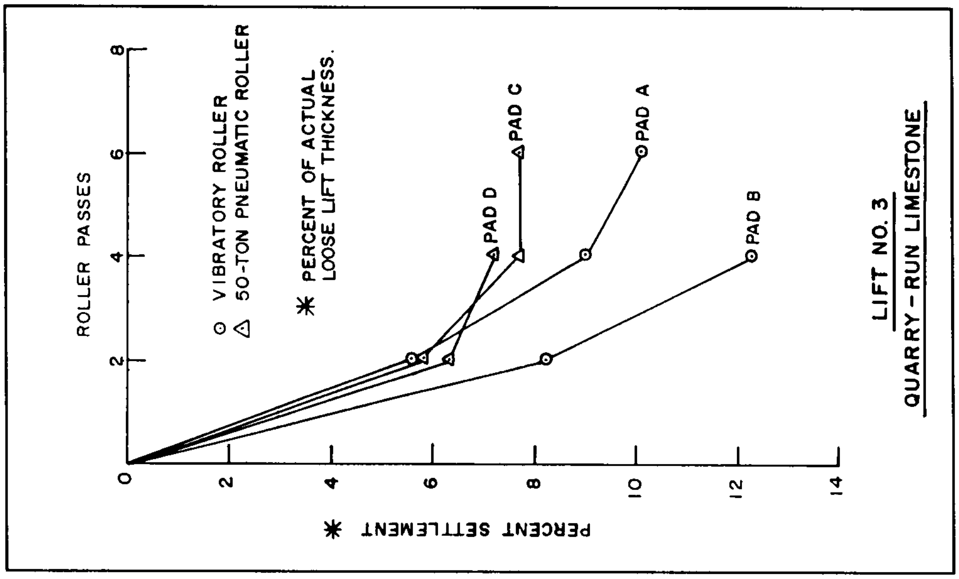

Figure 12-2. Percent settlement versus roller passes, lift 3, test fill 4A, Cerrillos Dam

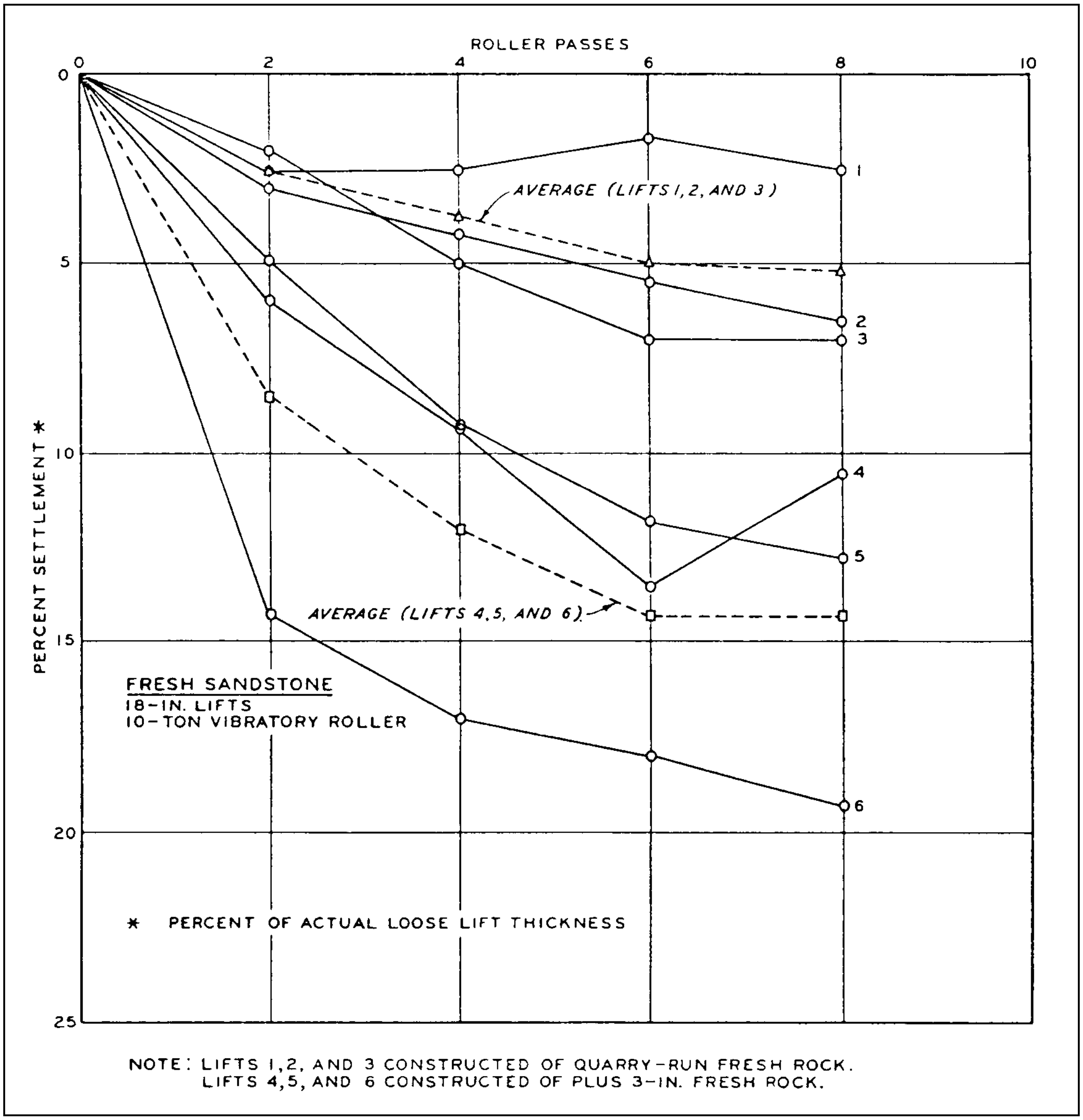

Figure 12-3. Percent settlement versus roller passes, Gilham Dam test fill

The portion of these data given in Figures 12-13 through 12-18 show in situ densities achieved by different rollers for a 45.7-cm (18-in.) lift thickness over a range in number of passes for the variety of rock types involved. Figures 12-13 through 12-15 show the actual results of the in situ density tests. The range of densities indicated are typical of those seen for rockfill materials. Because of the variation in the gradations of the full-scale material derived from the density tests including a range in maximum particle size, the Los Angeles District personnel astutely realized that direct comparison of the density values of Figures 12-13 through 12-15 was not valid. To compare the performance of the rollers on a common basis, it was decided to correct the fill density test values to those corresponding to the minus 7.6-cm (3-in.) and minus 3.8-cm (1.5-in.) fractions of each fill density sample. The correction was by use of the equation given in EM 1110-2-1911, Appendix B (see paragraph 11-2*c*, equation 11-1) where the gradation curve for each full-scale density sample was used to obtain the percent coarse fraction and percent fine fraction. In correcting the total material density to that of the minus 7.6-cm (3-in.) fraction within it, the percent coarse fraction "c" was the percent retained on the 7.6-cm (3-in.) sieve and the percent fine fraction "f" was then 1-c. Likewise, to correct

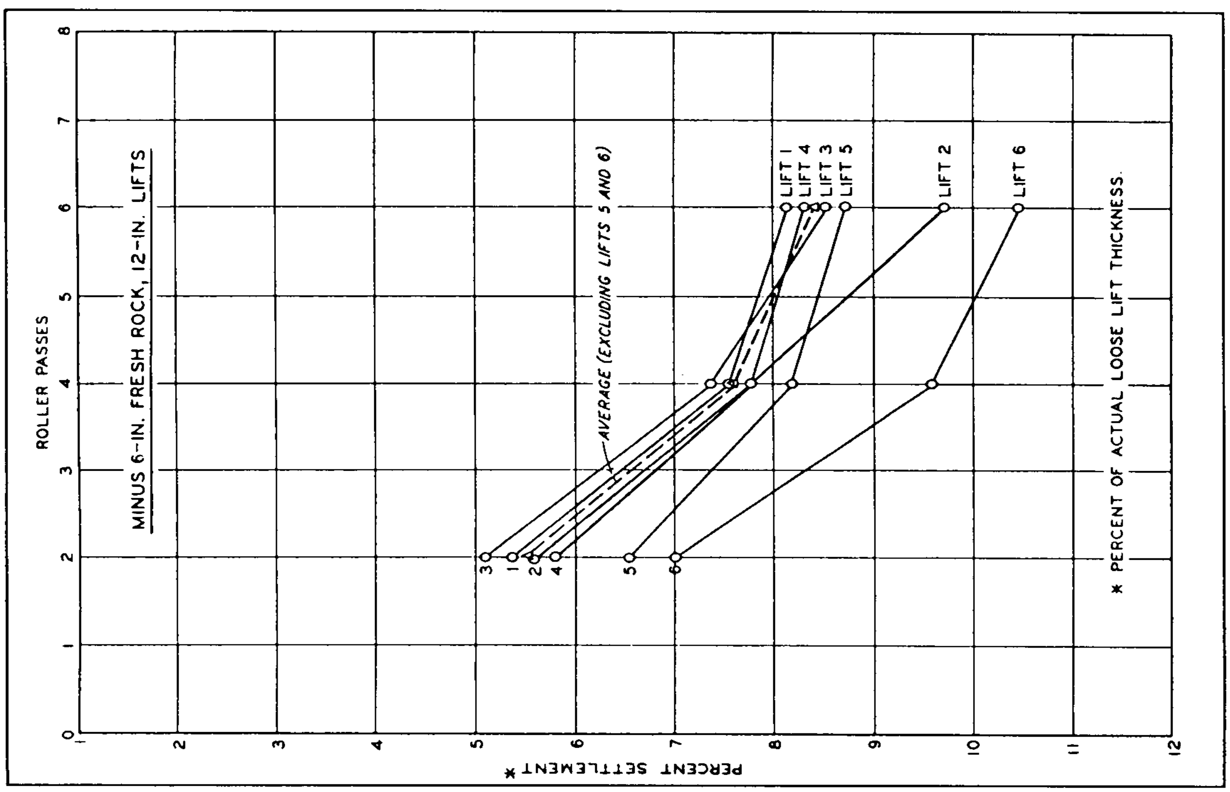

Figure 12-4. Percent settlement versus roller passes, test fill 3, New Melones Dam

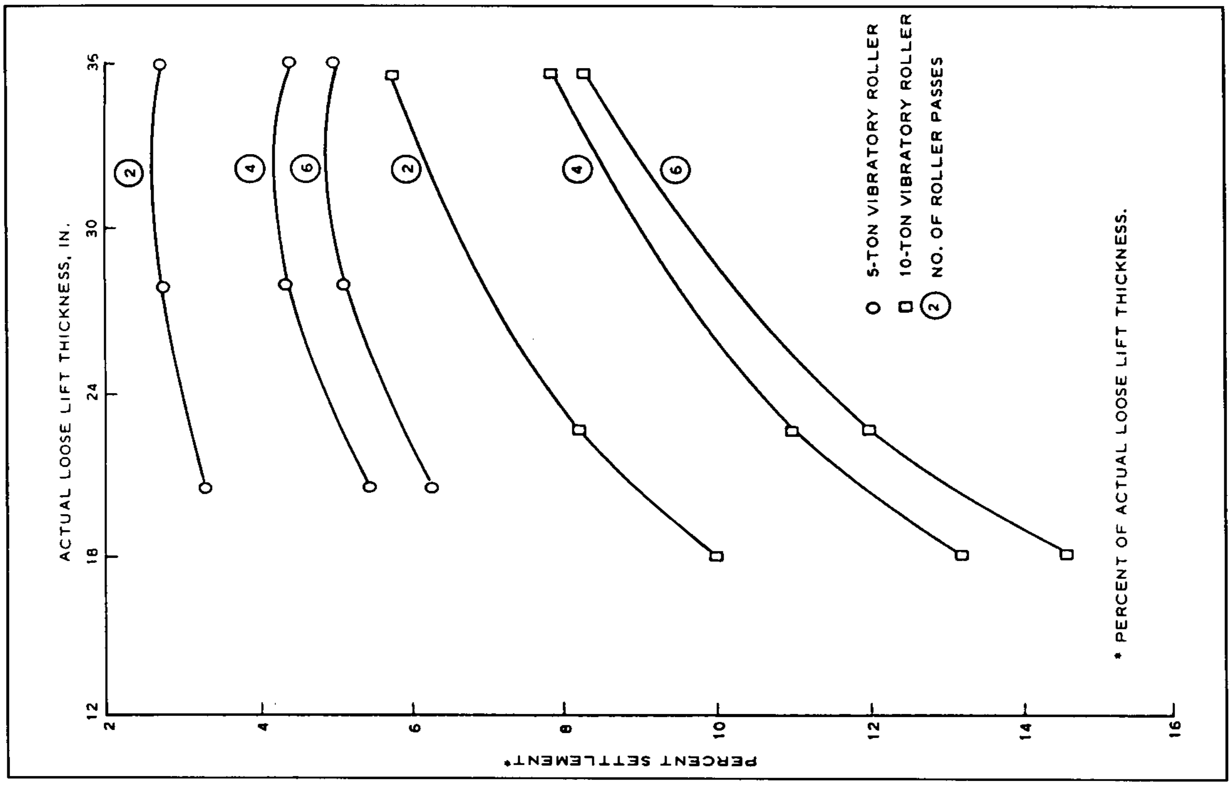

Figure 12-5. Percent settlement versus actual loose-fit thickness, test fill series 2, Cougar Dam

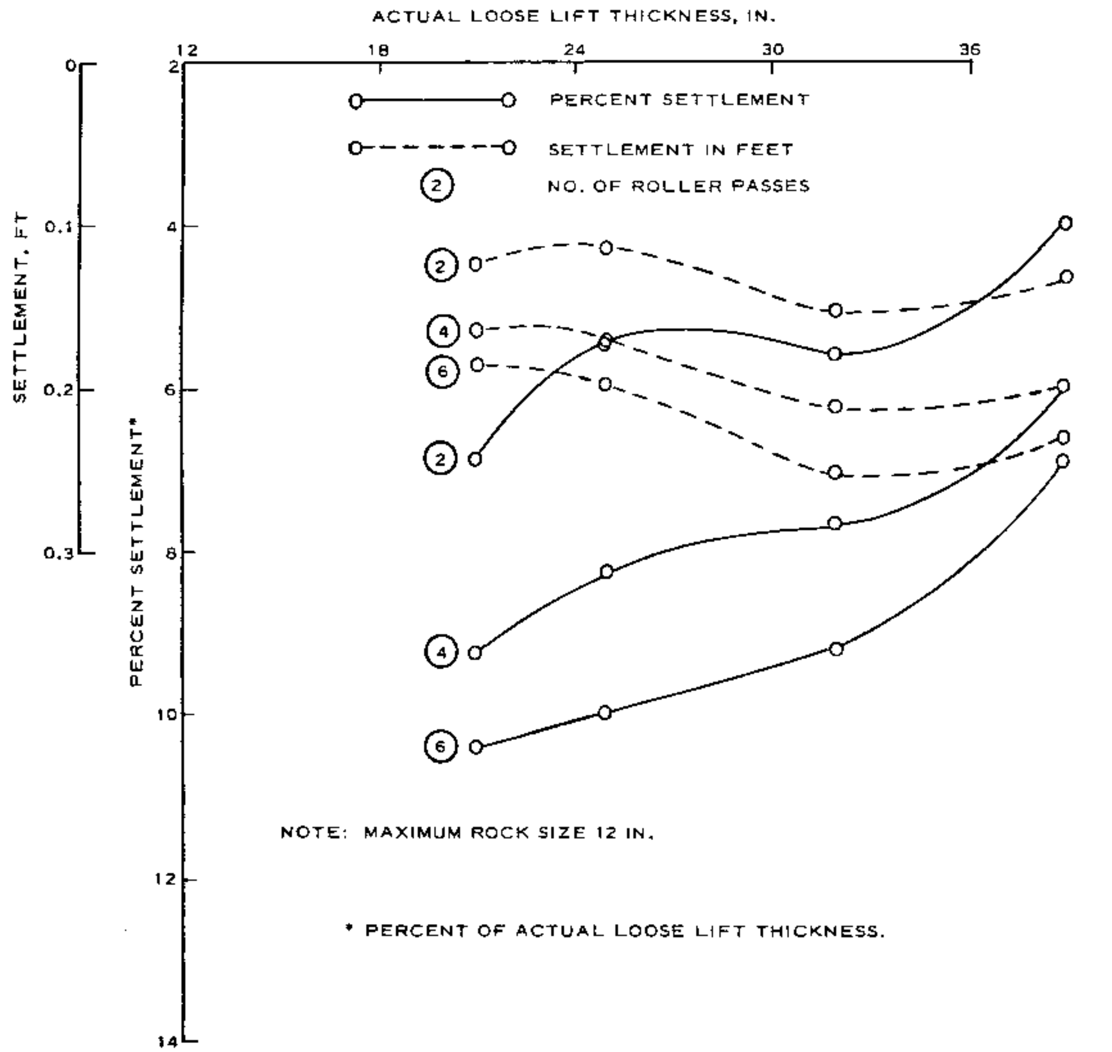

Figure 12-6. Percent settlement versus actual loose-fit thickness, test fill series 3, Cougar Dam

the total material density to that of the minus 3.8-cm (1.5-in.) fraction within it, the percent coarse fraction "c" was that retained on the 3.8-cm (1.5-in.) sieve. Figures 12-16 through 12-18 show the data of Figures 12-13 through 12-15 corrected to the densities of the minus 7.6-cm (3-in.) fractions. It is seen that the 45.3-Mg (50-ton) rubber-tired roller performed about as well as the vibratory rollers. As a matter of interest, the recommended compaction procedure for the rockfill of Seven Oaks Dam shell became a 45.7-cm (18-in.) loose lift thickness and 6 passes of the 9.1-Mg (10-ton) vibratory roller. For "dirtier" rockfill of the same parentage as the shell materials, a rockfill transition zone was provided downstream of the core of the dam, and its recommended compaction was 30.5-cm (12-in.) loose lifts and 4 passes of the 9.1-Mg (10-ton) vibratory roller.

12-6. Inspection Trench

Figures 12-19 through 12-22 are provided as examples of inspection trench observations. Figure 12-19 shows the sound rockfill for New Melones Dam where the important interlocking of the larger particles is evident with

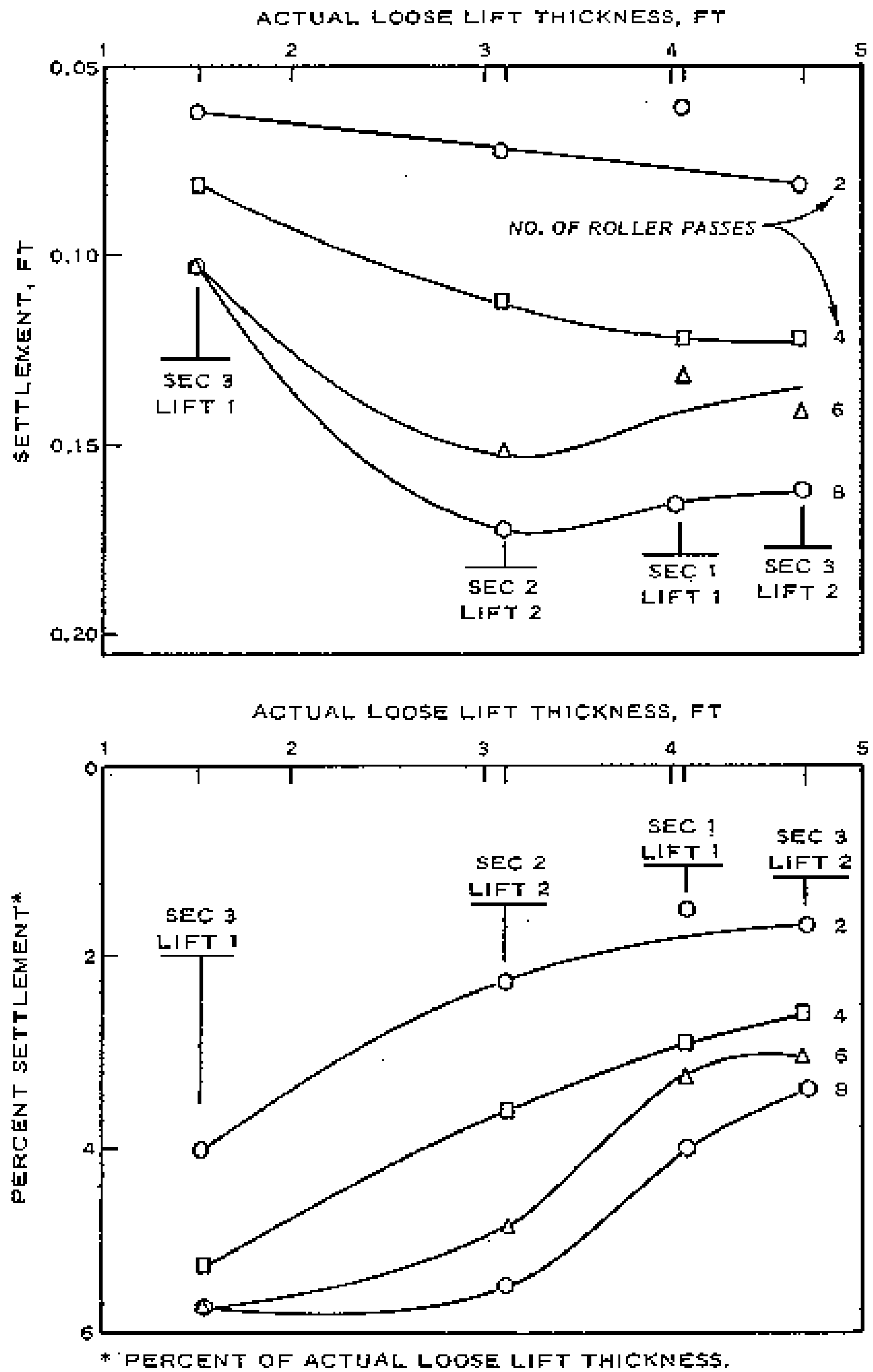

Figure 12-7. Percent settlement versus actual loose-fit thickness, Laurel Dam test fill

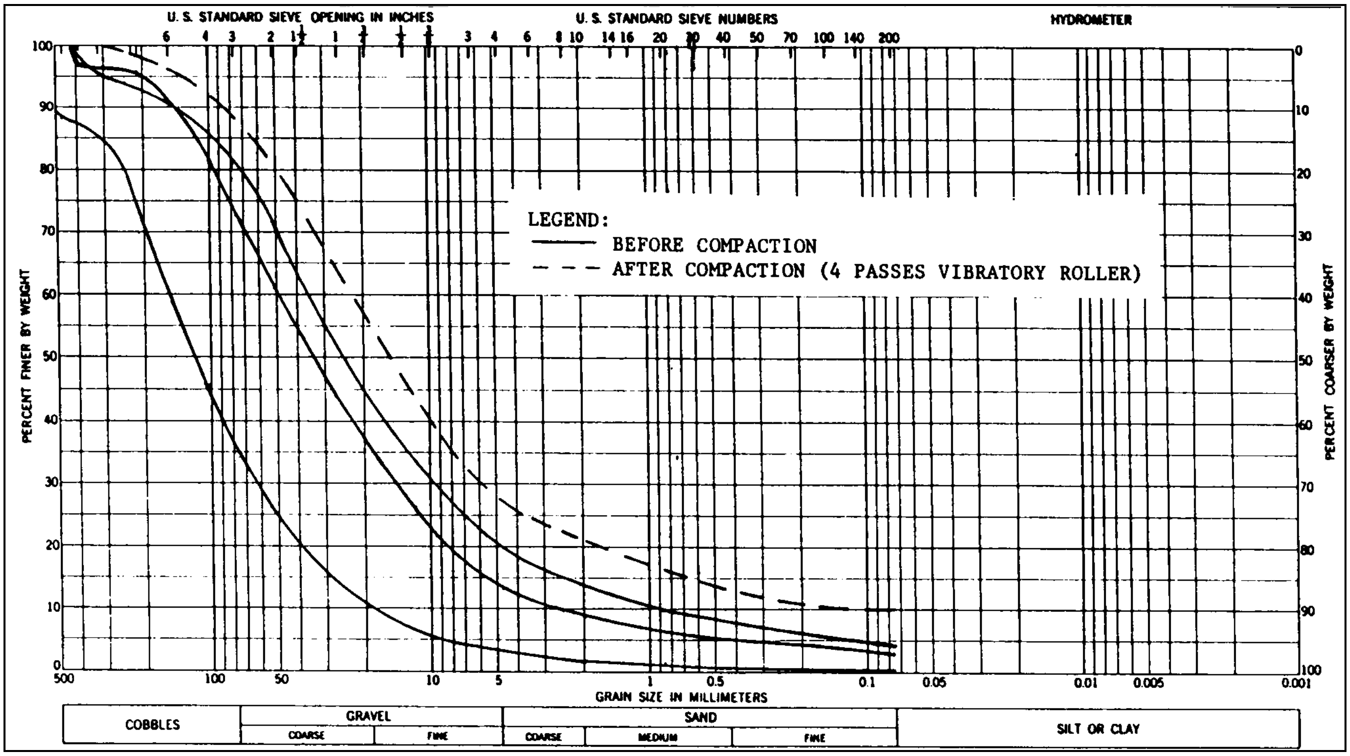

Figure 12-8. Before and after-compaction gradations after 4 passes of the vibratory roller, quarry-run siltstone, Cerrillos Dam

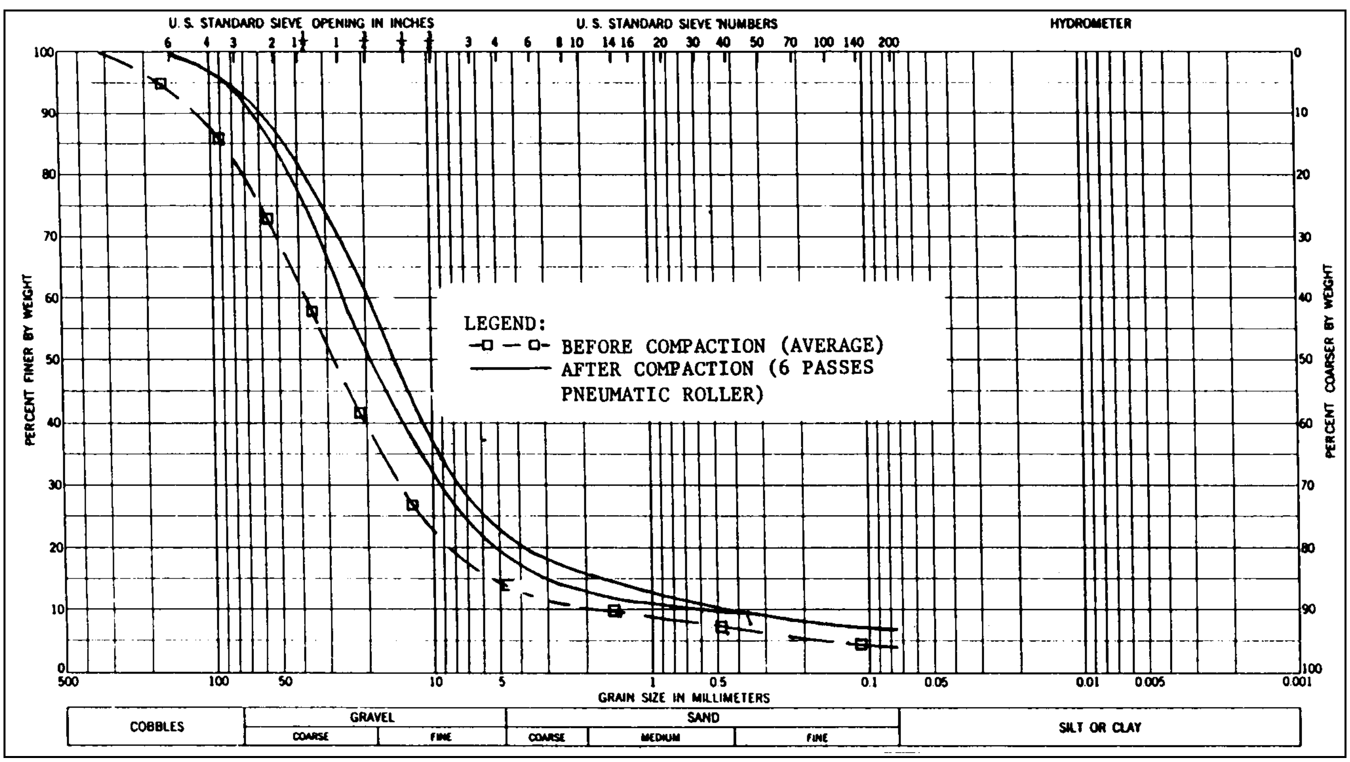

Figure 12-9. Before and after-compaction gradations after 6 passes of the pneumatic roller, quarry-run siltstone, Cerrillos Dam

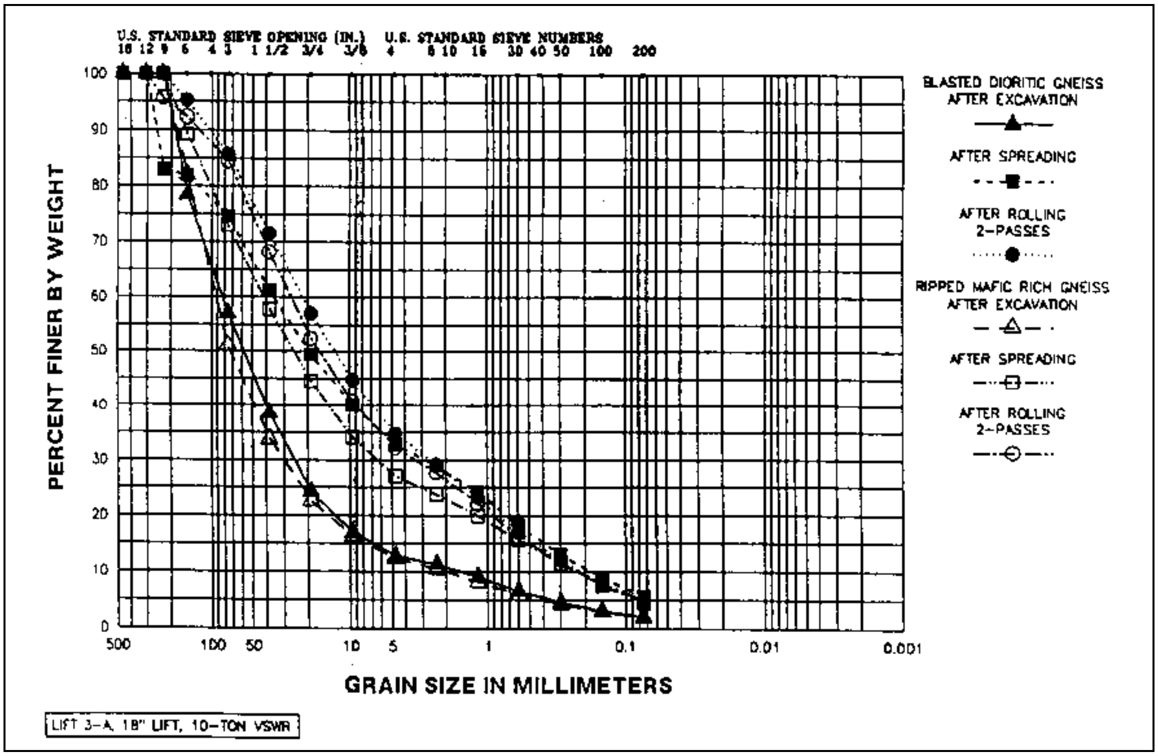

Figure 12-10. Change in gradation after 2 passes of 9.1-metric ton (10-ton) vibratory roller, 45.7-cm (18-in.) lift, Seven Oaks Dam materials

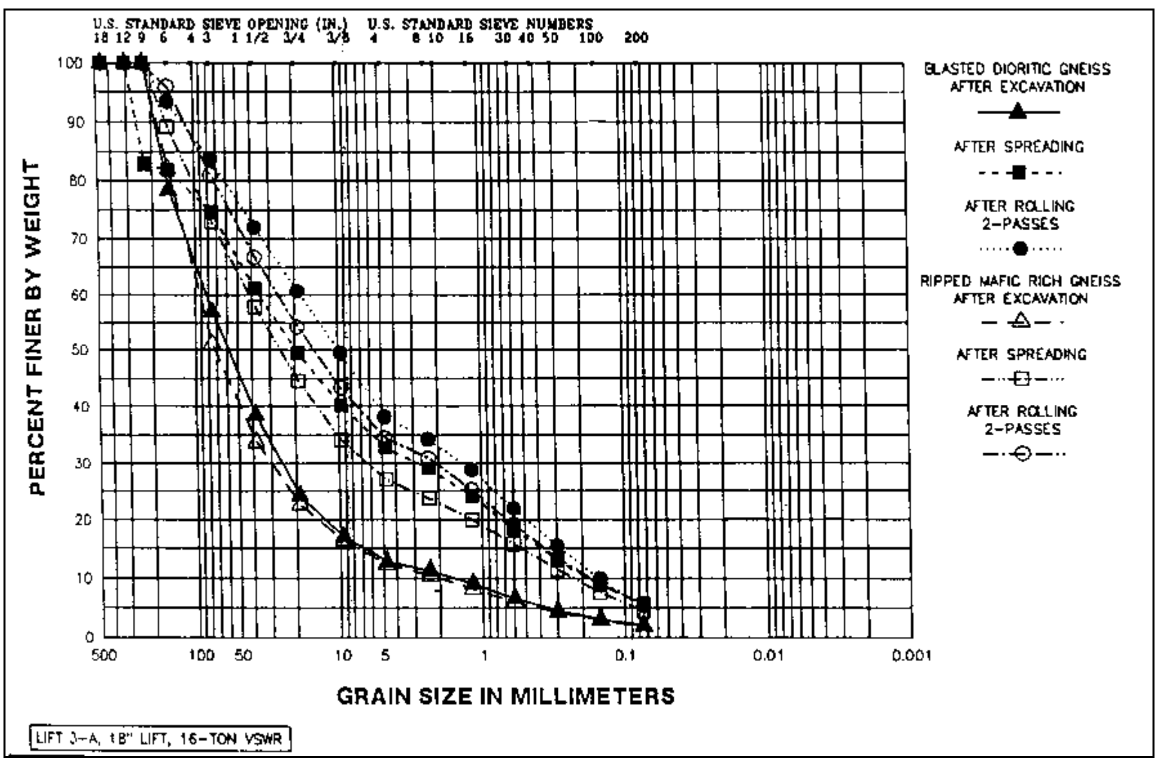

Figure 12-11. Change in gradation after 2 passes of 14.5-metric ton (16-ton) vibratory roller, 45.7-cm (18-in.) lift, Seven Oaks Dam materials

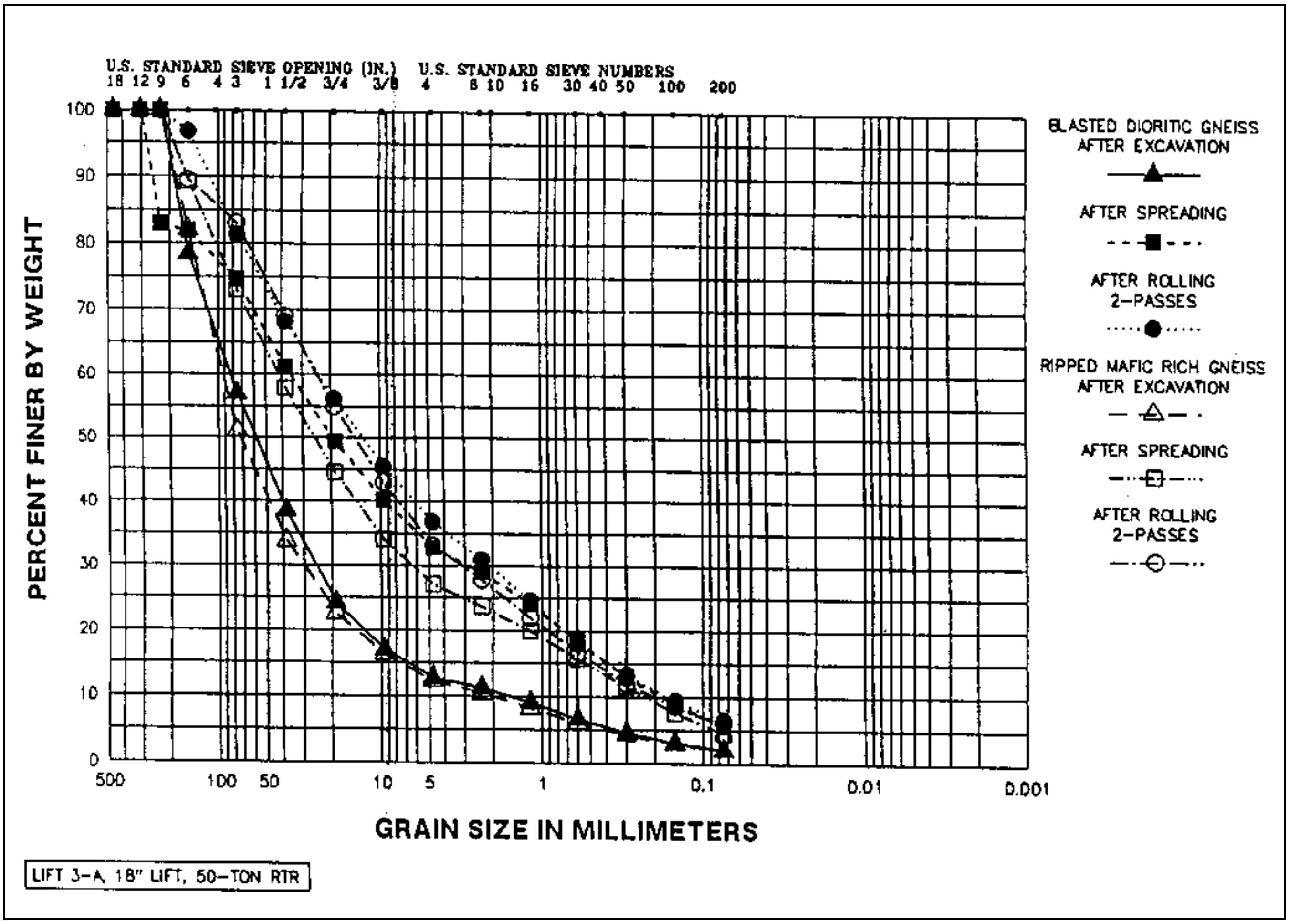

Figure 12-12. Change in gradation after 2 passes of 45.4-metric ton (50-ton) rubber-tired roller, 45.7 cm (18-in.) lift, Seven Oaks Dam materials

relatively little fines distributed throughout. Figure 12-20 shows a New Melones material with considerable fines where the overall uniform density with no significant segregation is apparent. It is also noted from the lower photograph of Figure 12-20 that the lifts are very nicely bonded as indicated by no indication of lift boundary other than the lime lift marker material (very thin, horizontal white seam across the photo). Figures 12-21 and 12-22 are from the test fills for Cerrillos Dam and also show the relative compactness and uniformity of that material containing appreciable fines.

12-7. Test Fill Report

After completion of the test fill program, a comprehensive formal report should be prepared as a project Design Memorandum in its own right or as a major portion of a Design Memorandum. Where a test quarry program was also performed in conjunction with the test fill program, the comprehensive report should treat both subjects. A typical test quarry and test fill report outline is given in Table 12-1. The test quarry portion of Table 12-1 was previously suggested in Table 7-1.

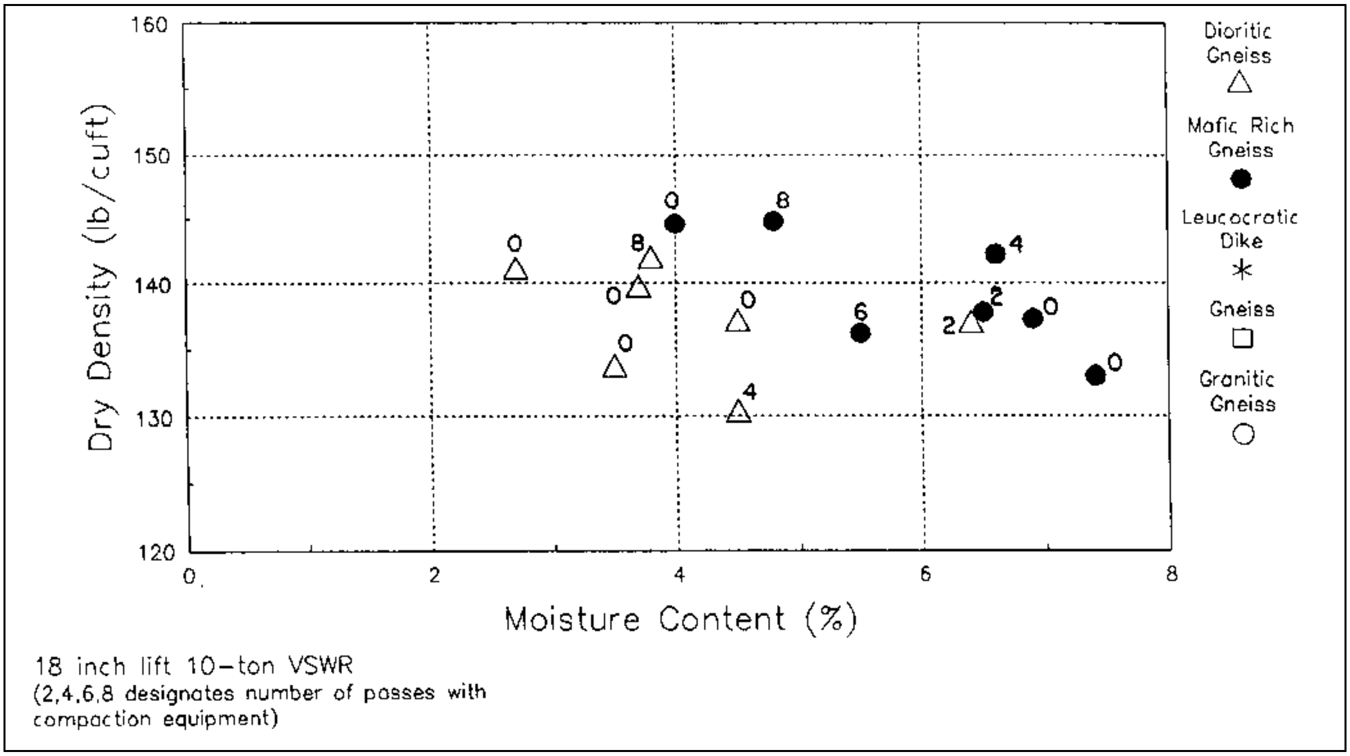

Figure 12-13. In situ density tests, 45.7-cm (18-in.) lift, 9.1-metric ton (10-ton) vibratory roller, Seven Oaks Dam materials

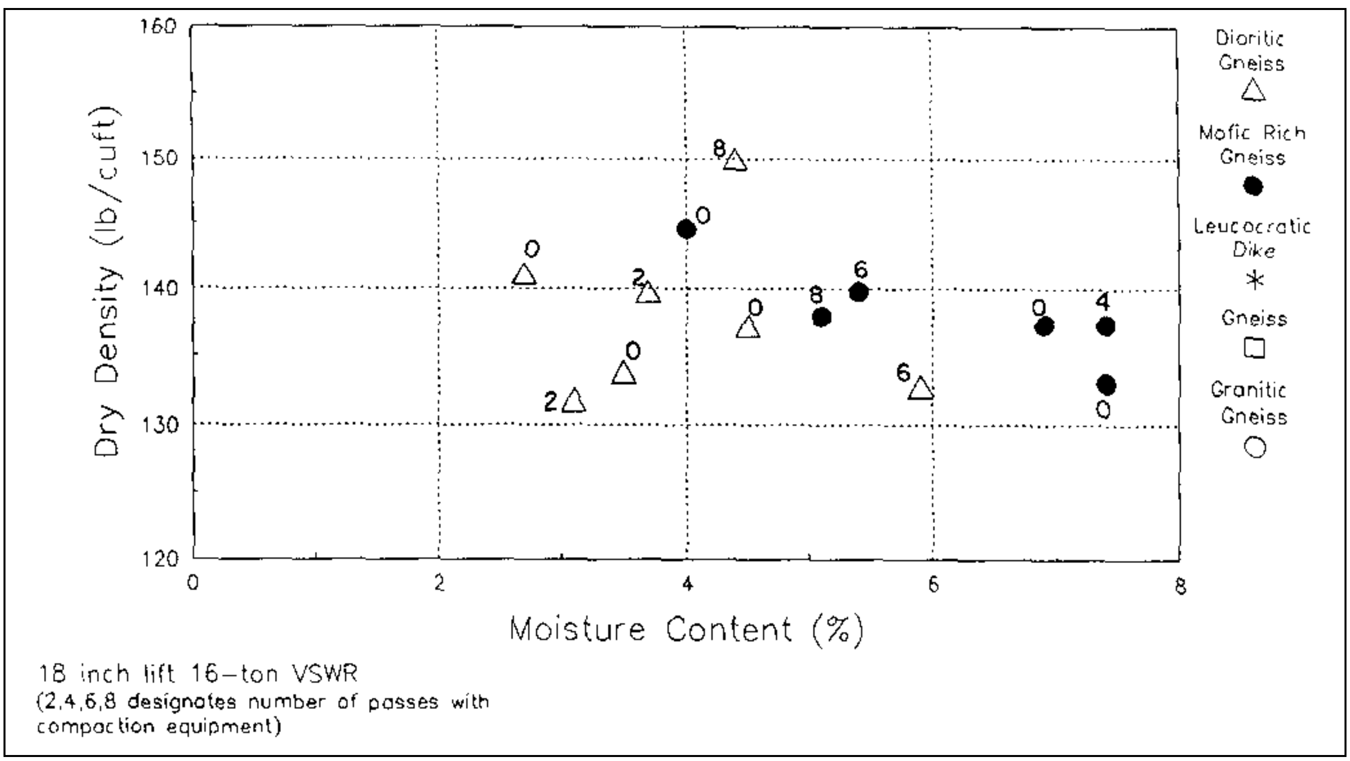

Figure 12-14. In situ density tests, 45.7-cm (18-in.) lift, 14.5-metric ton (16-ton) vibratory roller, Seven Oaks Dam materials

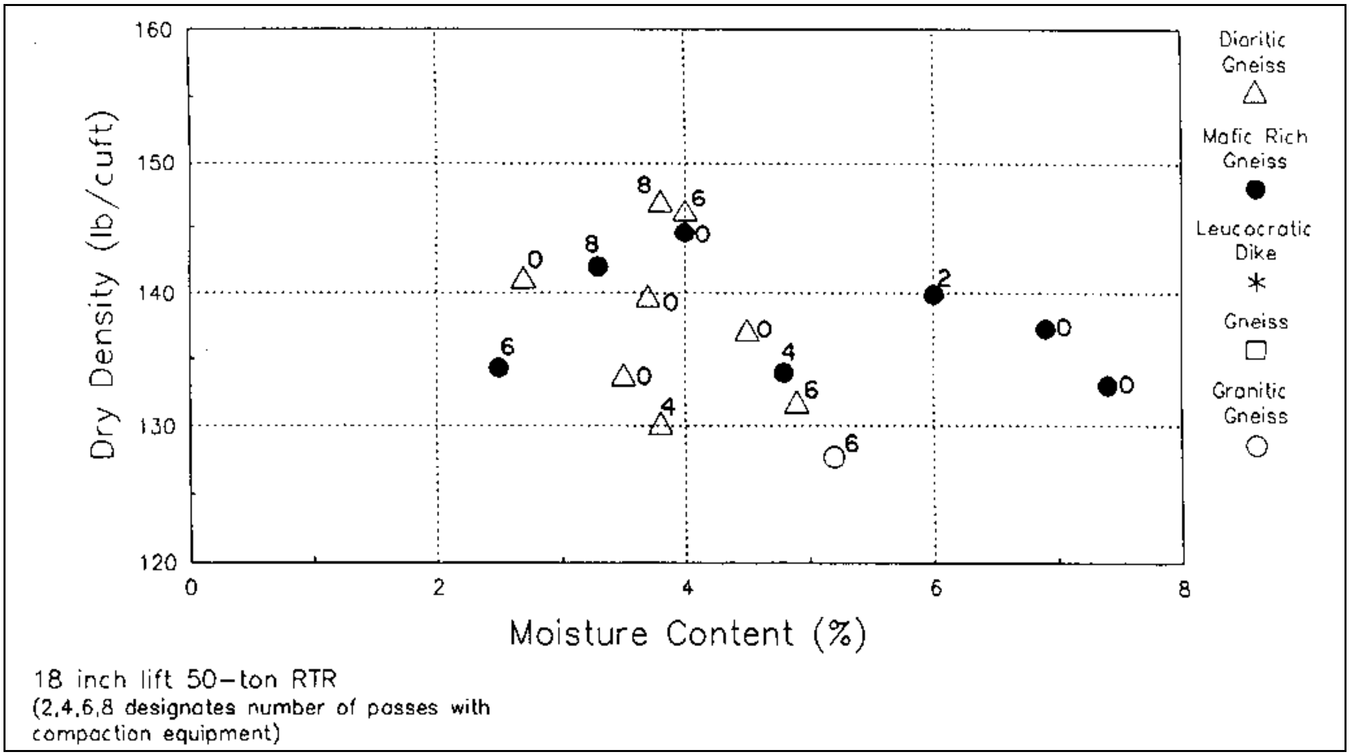

Figure 12-15. In situ density tests, 45.7-cm (18-in.) lift, 45.4-metric ton (50-ton) rubber-tired roller, Seven Oaks Dam materials

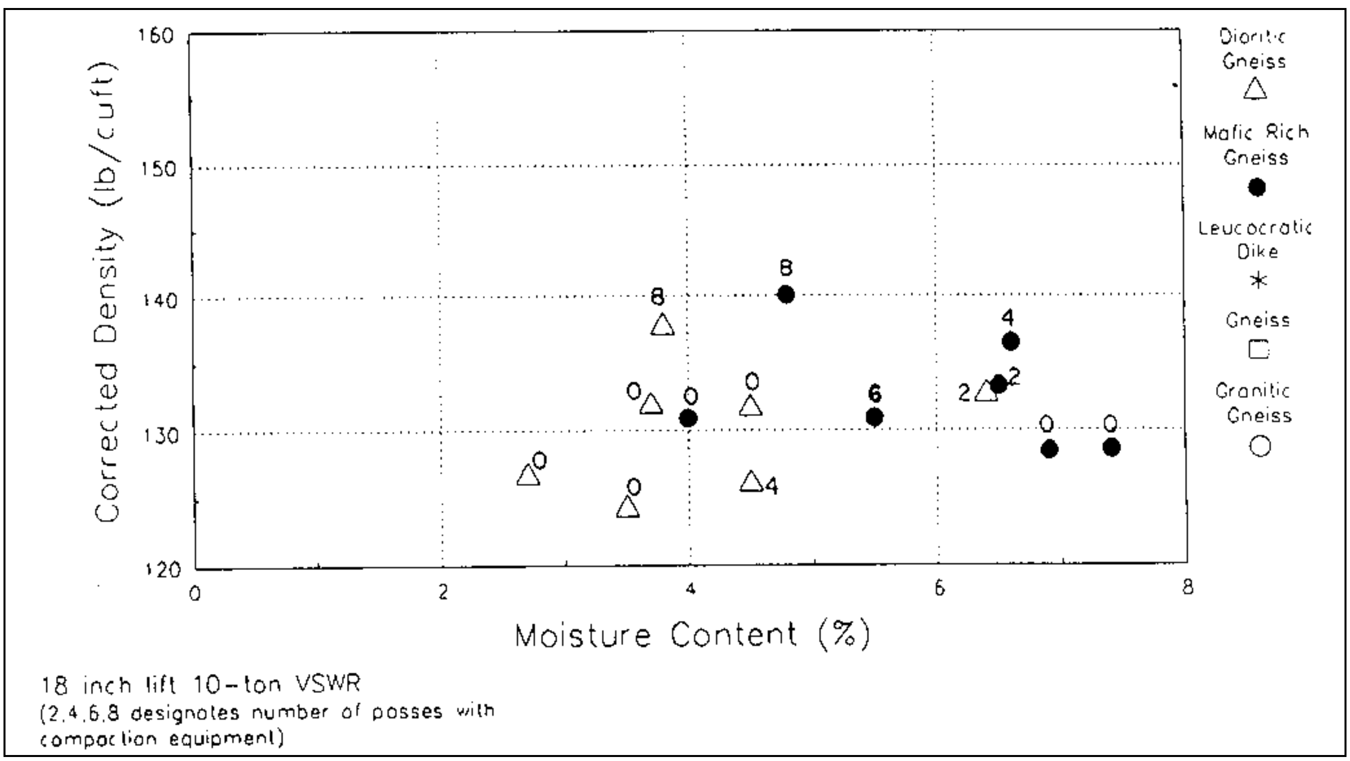

Figure 12-16. Corrected in situ densities, 45.7-cm (18-in.) lift, 9.1-metric ton (10-ton) vibratory roller, Seven Oaks Dam materials

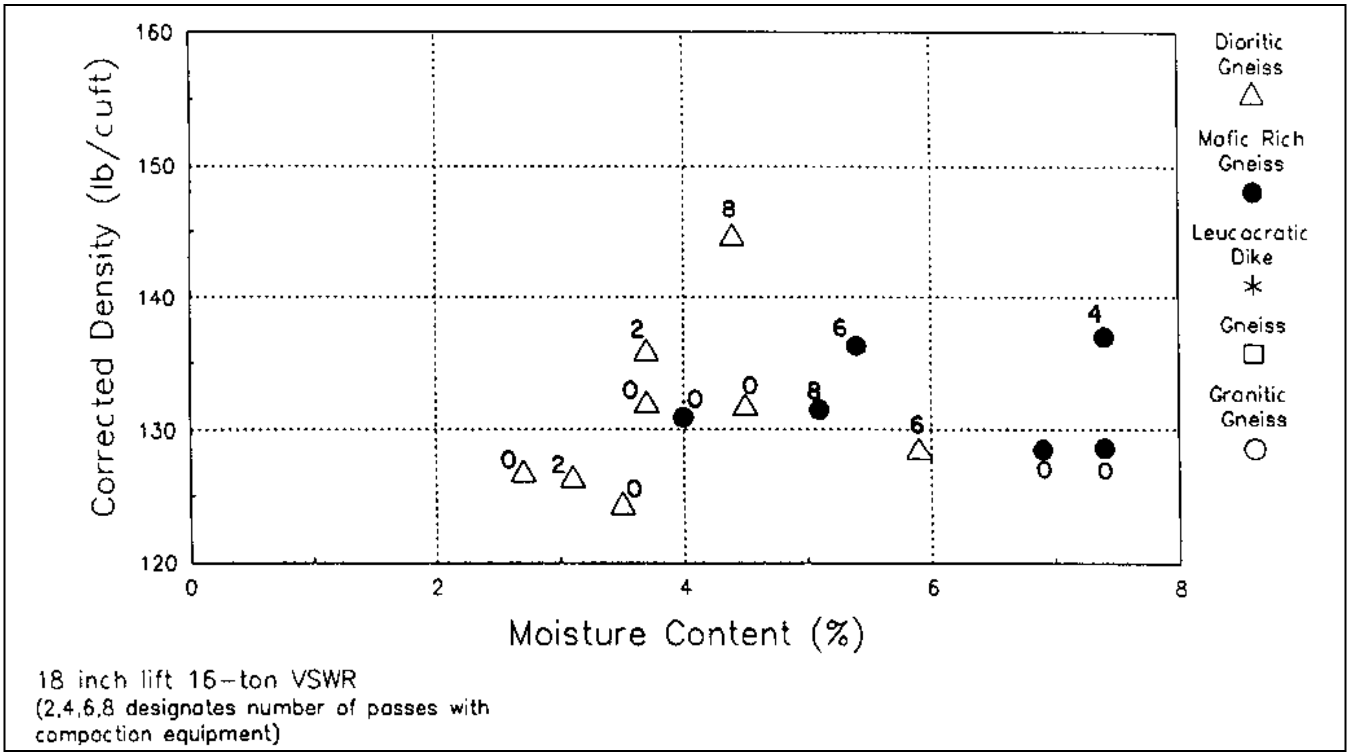

Figure 12-17. Corrected in situ densities, 45.7-cm (18-in.) lift, 14.5-metric ton (16-ton) vibratory roller, Seven Oaks Dam materials

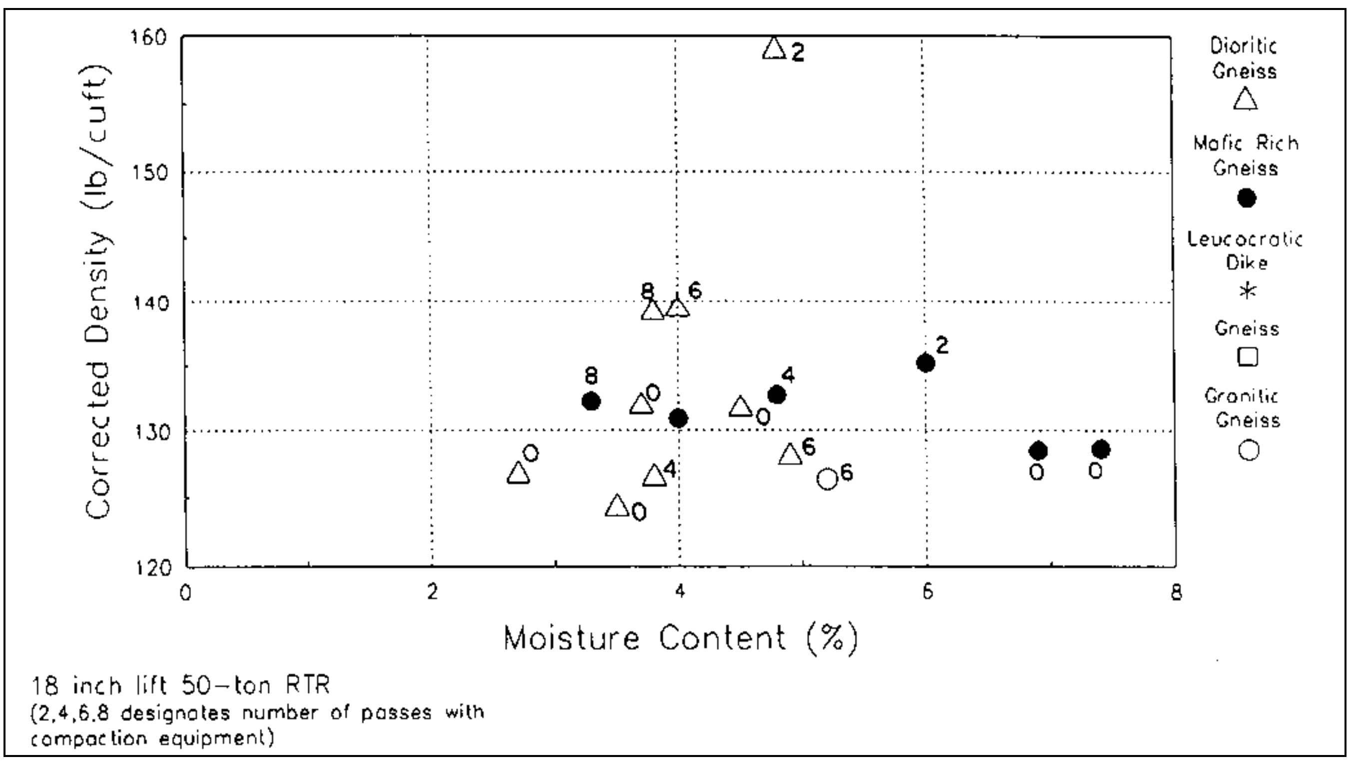

Figure 12-18. Corrected in situ densities, 45.7-cm (18-in.) lift, 45.4-metric ton (50-ton) rubber-tired roller, Seven Oaks Dam materials

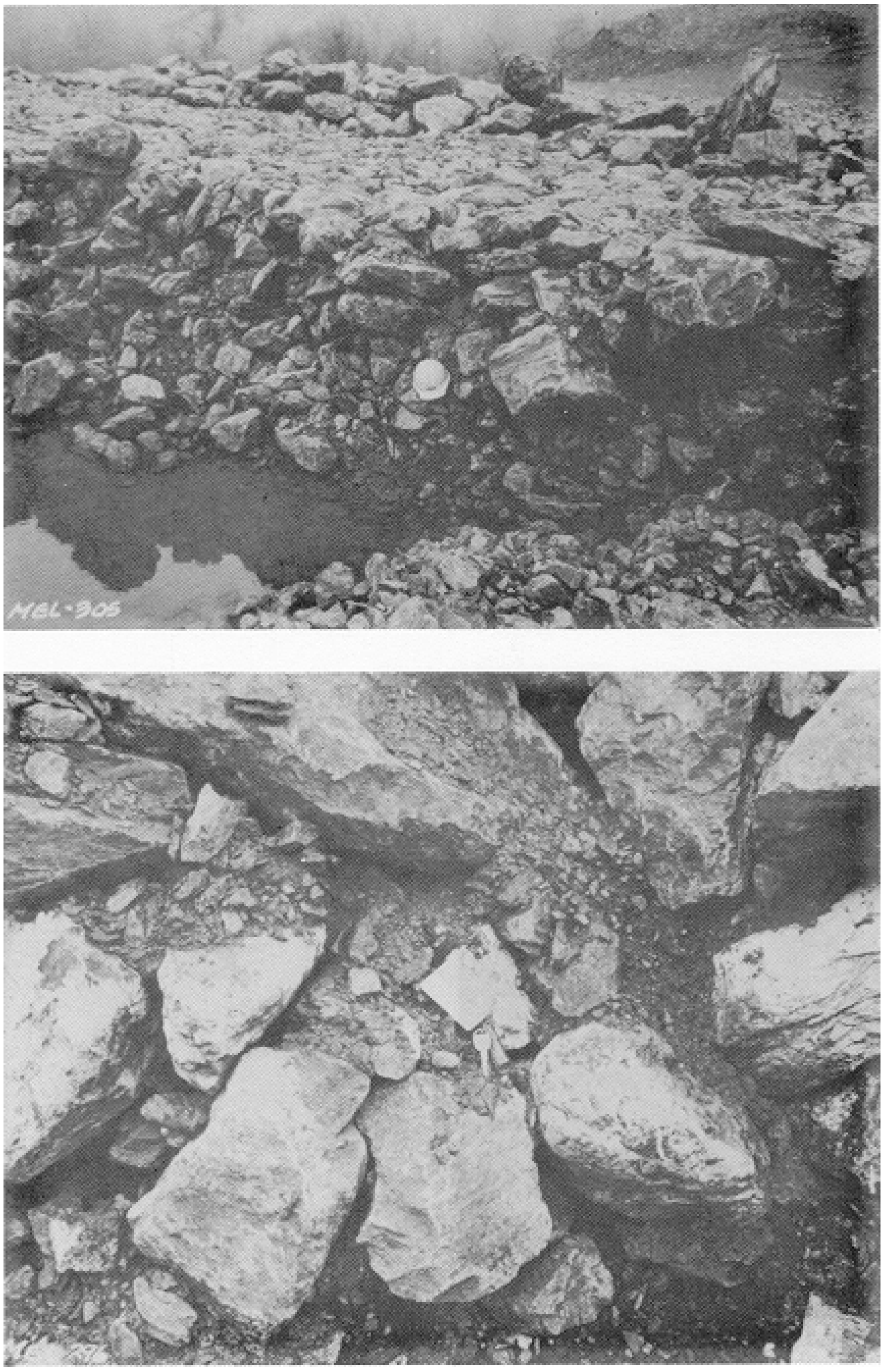

Figure 12-19. Photographs of sound rockfill, New Melones Dam test fill inspection trench

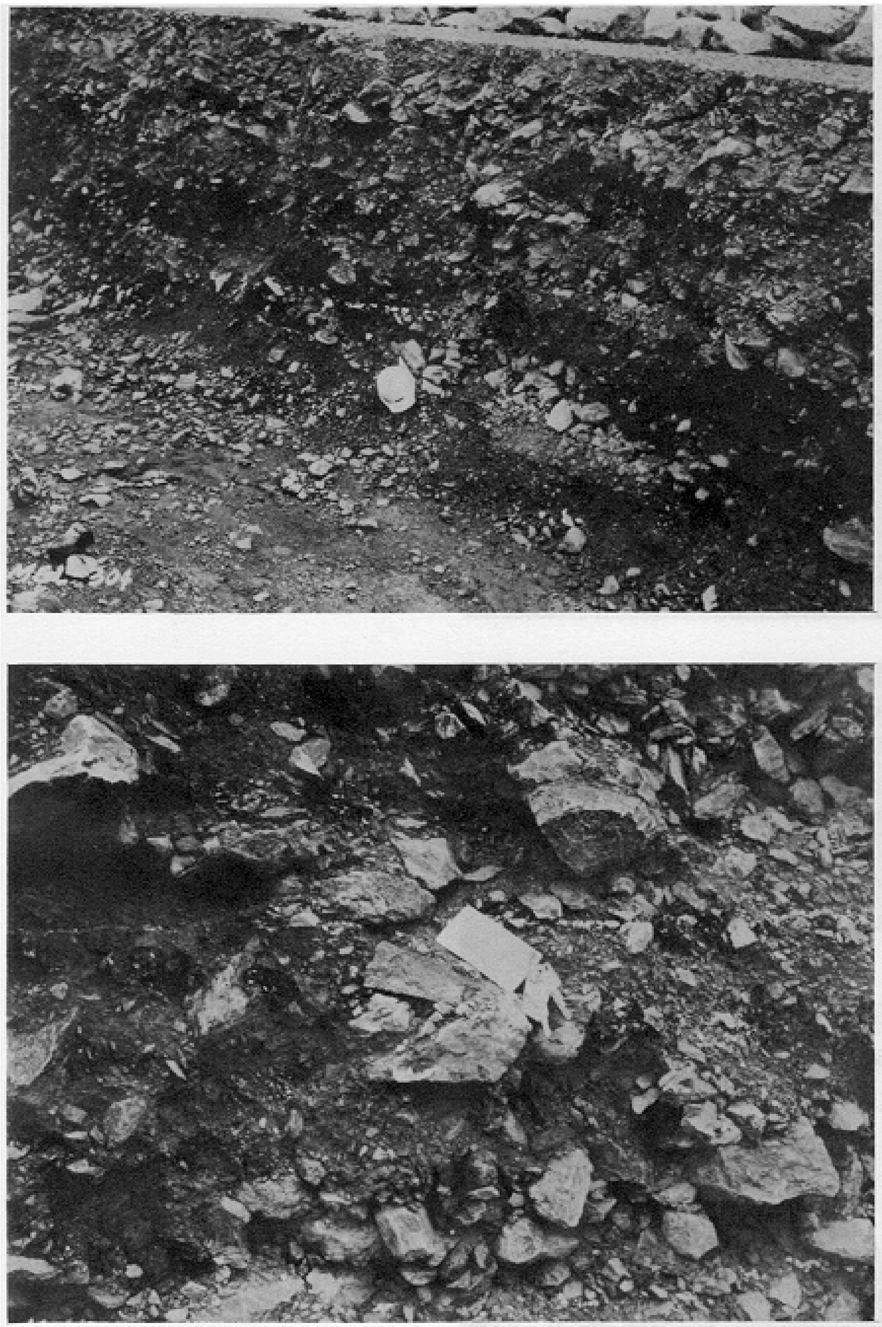

Figure 12-20. Photographs of rockfill containing appreciable fines, New Melones Dam test fill inspection trench

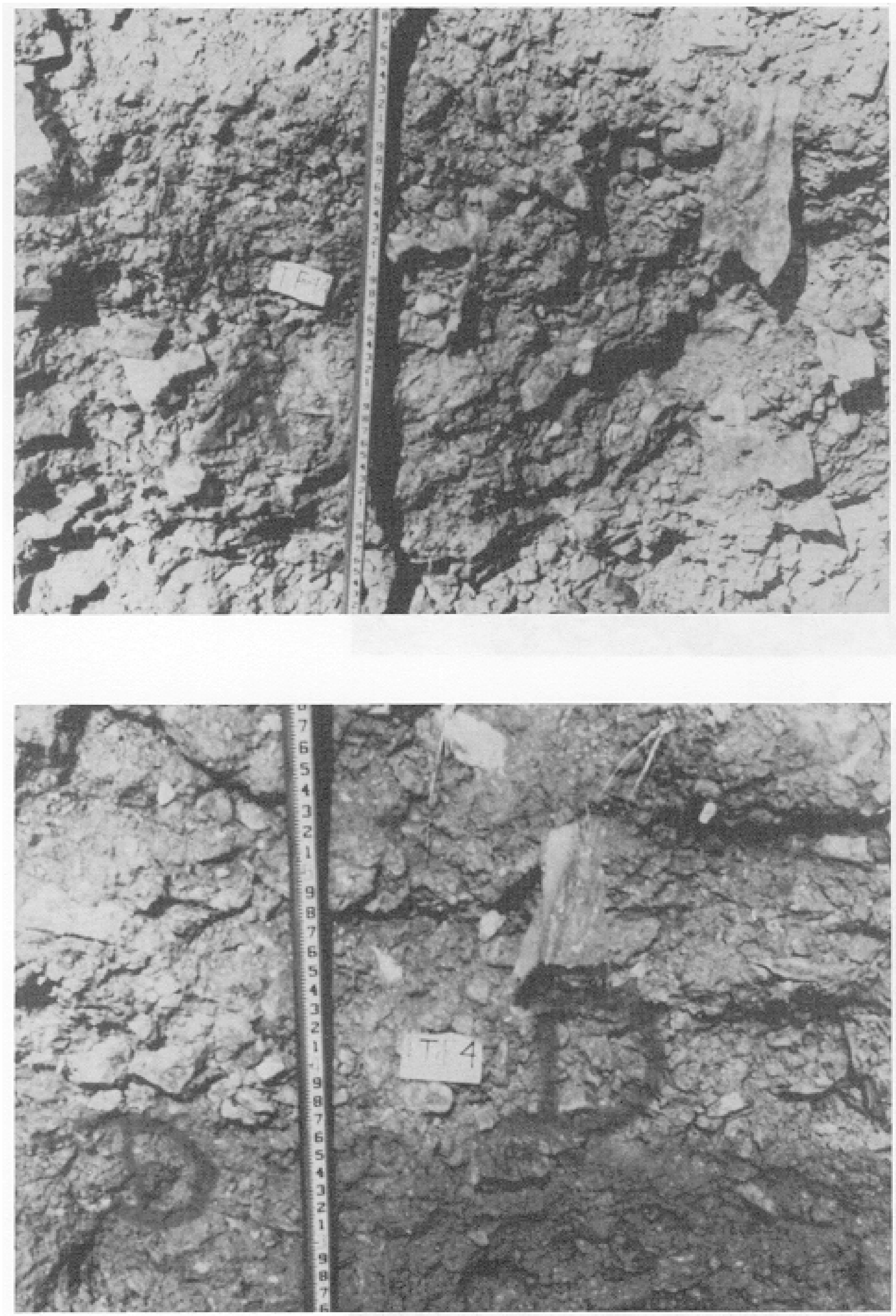

Figure 12-21. Photographs of rockfill containing appreciable fines, Cerrillos Dam test fill No. 4 inspection trench

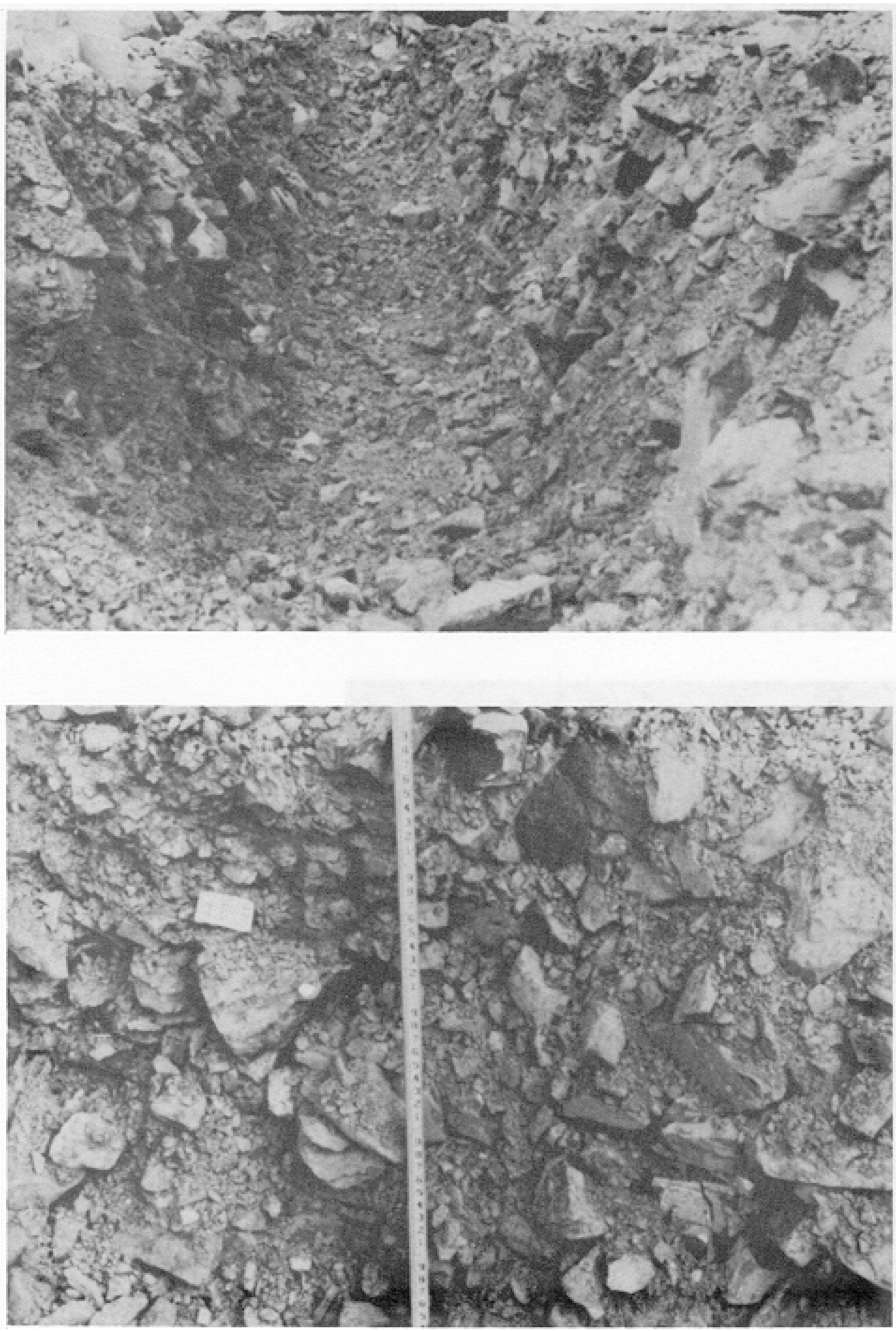

Figure 12-22. Photographs of rockfill containing appreciable fines, Cerrillos Dam test fill No. 5 inspection trench

Table 12-1
Typical Test Quarry and Test Fill Report Outline

1. Executive Summary

2. Table of Contents

3. Section 1 - Introduction

   a. Authorization
   b. Scope and purpose
   c. Location of the project

4. Section 2 - Site Geology

   a. Topography
   b. Geology

5. Section 3 - Project Plan

   a. Project features utilizing rockfill
   b. Expected borrow sources and locations

6. Section 4 - Site Selection for Test Quarry and Test Fill

   a. General discussion of site selection factors and judgments including borehole information
   b. Selected locations of test quarry and test fill
   c. General preliminary site preparation such as removal of and destination of overburden, access road aspects, etc.

7. Section 5 - Test Quarry

   a. Test quarry design and objectives

      1) Discussion of objectives
      2) Overview of site selection criteria
      3) Thorough presentation of design including layout and slope stability

   b. Geological conditions in the test quarry
   c. Description of each test blast

      1) Rock type and condition
      2) Hole pattern
      3) Delay pattern
      4) Hole depths and loading design
      5) Explosives, detonators, and delays
      6) Blasted rock mass description
      7) Quarry-run gradation
      8) Laboratory tests and results
      9) Conclusions

   d. Drilling, loading, and hauling equipment and procedures
   e. Description of the results of each presplit slope blast

      1) Rock type and condition
      2) Presplit hole and explosive charge configuration
      3) Presplit slope condition
      4) Rock joint analysis and slope stability
      5) Conclusions

(Continued)

Table 12-1 (Concluded)

f. Rock processing results

1) Description of processing objective
2) Description of rock processing equipment
3) Results of processing each rock type and condition
4) Gradations and particle shapes
5) Degradation during each stage of processing
6) Laboratory tests and results

g. Conclusions and recommendations

8. Section 6 - Test Fill

a. Description of the test fill program including materials, layout, and compaction equipment to be assessed
b. Description of tests and measurements to be performed

1) Description of test procedures and schedule of tests
2) Locations including settlement grid layout

c. Foundation preparation

1) Description of the foundation
2) Treatment prior to leveling pad construction (if any) such as special rolling to reduce compressibility
3) Materials and construction of leveling pad, including equipment types
4) Justification for, locations of, descriptions of, and installation procedures for settlement plates

d. Construction
e. Field tests and measurements, i.e., in situ densities, gradations, etc.
f. Laboratory tests and results (if any)
g. Analysis and discussion of data

9. Section 7 - Inspection Pits or Trenches

a. Description of inspection pits or trenches and locations, method of excavation
b. Discussion of observations and any sampling

10. Section 8 - Conclusions and Recommendations

a. Conclusions including lessons learned
b. Recommendations

APPENDICES -- Laboratory Test Sheets, Boring Logs, Field Gradation Test Results, Description of Rock Processing Equipment, Photographic Documentation of All Aspects of Test Quarry and Test Fill, etc.